Transport Canada
Development

Transports Canada
Développement

TP 3756E

Augmented Rail Freight Transportation Research and Development Program

FINAL REPORT

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Transportation Development Centre

March 31, 1986

Canada

TP 3756E

AUGMENTED RAIL FREIGHT TRANSPORTATION RESEARCH AND DEVELOPMENT PROGRAM

FINAL REPORT

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Transportation Development Centre
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FOREWORD

The Augmented Rail Freight Transportation Research and Development Program originated as part of a $19 million augmented R&D program for Arctic Marine and Railway Freight Transportation approved by the Ministry of State for Economic Development (MSED) and by Cabinet Committee in June 1981, and subsequently, by Treasury Board in July 1981. The allocation to Rail Freight R&D was $5 million, with the Transportation Development Centre of Transport Canada (TDC) having authority for management of those funds. Funding in the amount of $1 million was authorized by Treasury Board for FY 1981/82 and $2 million for each of FY 1982/83 and FY 1983/84.

In accordance with the terms of that initial Treasury Board Authorization, the Program was evaluated during 1983 and on the basis of that evaluation, authorization was requested from Treasury Board for additional funding to enable extension of the Program over FY 1984/85 and FY 1985/86. In December 1983, Treasury Board authorized the program extension in the amounts of $2.1 million for FY 1984/85 and $2.2 million for FY 1985/86. Subsequently, the 1985/86 authorization was reduced to $1.9 million, bringing the Program total to $9.0 million.

The objective of the Program was to permit the railway supplier and operating industries to produce and deploy equipment and systems which will yield improvements in rail freight productivity, capacity, safety and costs, and improve Canada's ability to compete in domestic and foreign markets. The objective was to be achieved by:

a) increasing the federal railway R&D expenditures by participating with industry in a multi-year R&D program;

b) achieving stronger industry commitment to R&D and inducing investment in new Canadian railway technology.

In accordance with the Program Objective, program support has been provided by the railways and railway suppler industry through their commitment of both funds and resources. Additional leverage has been achieved through appropriate allocations from the Energy Research and Development Program and from other sources.

Implementation of the Program commenced in mid-1981. A status report was published at the end of FY 1981/82 and also at the end of each quarter since that date. All reports in this series bear the Transport Canada Publication Number TP 3756E. The initial three bear the title "MSERD Rail Freight Transportation Research and Development Program", and the appropriate subtitle (Year-End or Quarter). Commencing with the third quarter report FY 1982/83, the title was changed to "Augmented Rail Freight Transportation Research and Development Program" (ARFP).

The end of FY 1985/86 marked the end of the augmented rail freight R&D funding and this document is thus the last in the series of quarterly and annual reports on the Program. It therefore includes a brief overview of the Program content and benefits in addition to the usual information on accomplishments, new projects added and disbursements during the quarter.

1. PROGRAM OVERVIEW

1.1 Program Content and Participants

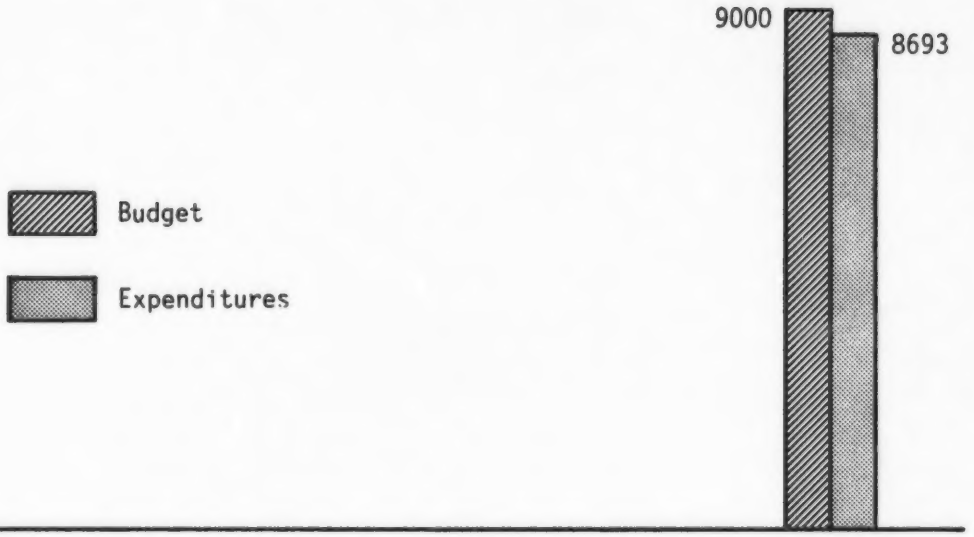
At its termination on March 31, 1986, the Program included a total of 87 different research projects within five major program elements - Motive Power, Freight Cars, Intermodal, Infrastructure and Maintenance, Communication and Automation. Those projects of an adminstrative nature, e.g. DSS contracting, program evaluation, etc., were contained in a sixth element, Program Support.

Seven Canadian railways and six firms from the Canadian railway supplier industry contributed funds and/or resources to the Program - CP Rail, CN Rail, B.C. Rail, Cartier Railway Company, Quebec North Shore and Labrador Railway, VIA Rail, Ontario Northland Railway, Bombardier Inc., Brown Boveri Canada Ltd., Glenayre Electronics, Speno Rail Services Company, Dominion Textiles and Vale Enterprises. Additional funding was provided by the Energy Research and Development Program, DSS Bridge Fund and the TDC O&M budget. Thirty-seven different contractors/subcontractors were employed in carrying out the work.

As of March 31, 1986, 64 of the 87 research projects had been completed, including submission and acceptance of all contract deliverables - normally a final report on the work. Those projects are listed in Appendix 3 and the associated reports in Appendix 2. Work on six of the 23 projects categorized as active as of March 31st had been completed but the final report had not been received/approved. To enable completion of the remaining 17 projects, the unexpended portion of the ARF funding allocated for those projects will be replaced with funding through the TDC O&M budget or, in the case of those projects funded partially by another federal government department (sponsor), by that department.

1.2 Program Financial Summary ($000)

1.2.1 ARFP Funds ($)



1.2.2 Other Federal Input ($ + resources)

Expenditures

DSS Bridge, Energy R&D, TDC O&M

NRC Resource Contribution

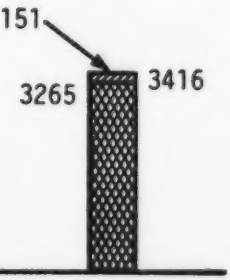
Committed for future years through uncompleted contracts awarded to end FY 1985/86

DSS Bridge, Energy R&D, TDC O&M

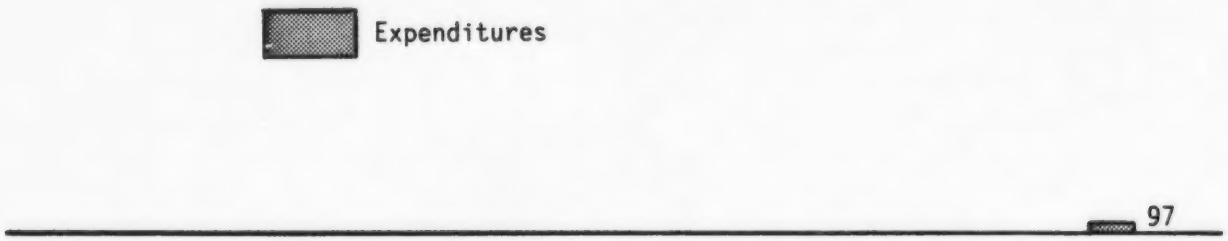
1.2.3 Industry Input ($ + resources)

Expenditures

Committed for future years to support work on uncompleted contracts awarded to end FY 1985/86



1.2.4 Province of Ontario Input ($)



1.2.5 Total Input all Sources ($ + resources)

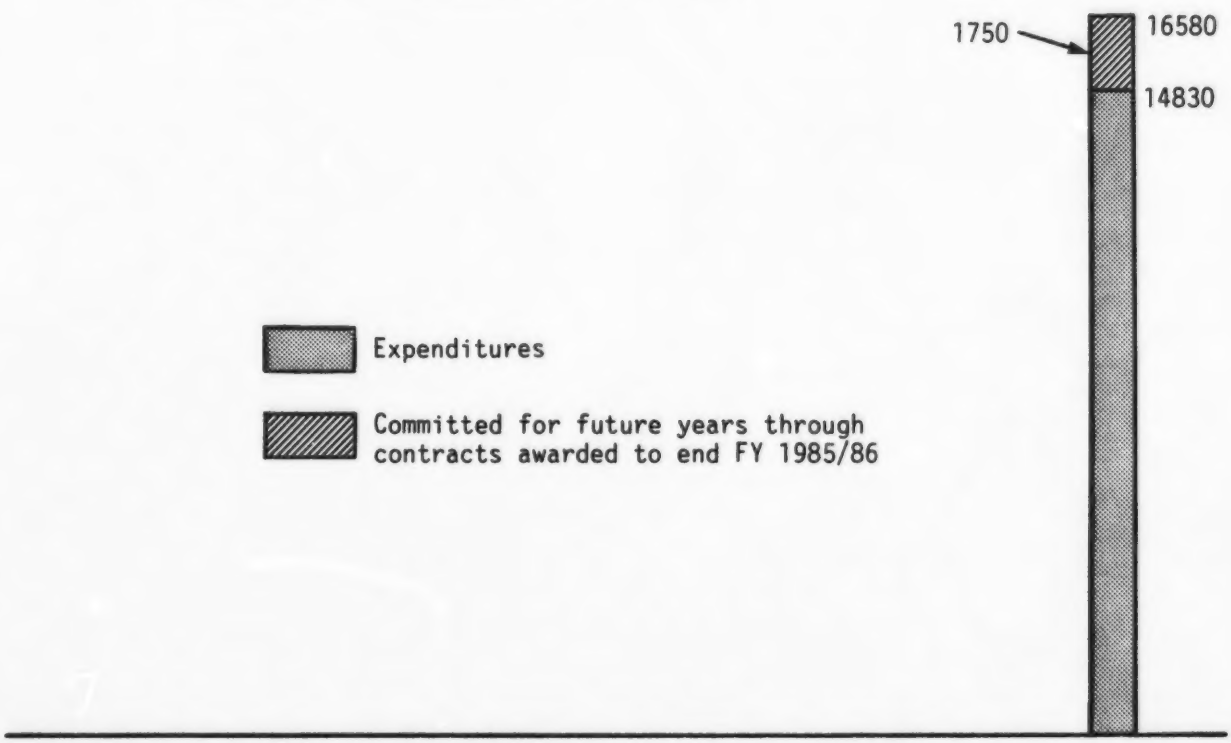


TABLE 1

ARF PROGRAM CONDENSED FINANCIAL SUMMARY

($000)

PROGRAM ELEMENT	AUTHORIZED					EXPENDITURES				
	ARFP	OTHER FEDERAL*		INDUSTRY		ARFP	OTHER FEDERAL*		INDUSTRY	
	$	$	RESOURCE	$	RESOURCE	$	$	RESOURCE	$	RESOURCE
1. MOTIVE POWER	3995.0	1897.4	0.0	43.8	1208.6	3765.9	1605.9	0.0	43.8	1109.4
2. FREIGHT CARS	1314.3	557.7(1)	0.0	0.0	103.0	1187.3	480.7(3)	0.0	0.0	103.0
3. INTERMODAL	354.3	43.0	0.0	0.0	284.4	354.3	43.0	0.0	0.0	284.4
4. INFRASTRUCTURE AND MAINTENANCE	1659.6	109.1	373.1	373.4	553.2	1283.6	109.1	373.1	343.4	543.2
5. COMMUNICATION AND AUTOMATION	1785.9	397.8	0.0	271.9	578.0	1632.2	260.4	0.0	271.9	565.9
6. PROGRAM SUPPORT	652.3	24.8	0.0	0.0	0.0	469.8	0.0	0.0	0.0	0.0
TOTAL $	9761.4 (Note A)	3029.8(2)		689.1		8693.1	2499.1(4)		659.1	
TOTAL RESOURCES			373.1		2727.2			373.1		2605.9
TOTAL PROGRAM	16580.6					14830.3				

*Except as noted below:
(1) Federal Govt. 460.6 Prov. of Ont. 97.1 Proj. 4729 (3) Federal Govt. 383.6 Prov. of Ont. 97.1 Proj. 4729
(2) Federal Govt. 2932.7 Prov. of Ont. 97.1 Proj. 4729 (4) Federal Govt. 2402.0 Prov. of Ont. 97.1 Proj. 4729

NOTE A:

Project schedules and budgets were planned to result in disbursement of the total ARFP budget of $9M by the end of FY 1985/86. It was known that work on certain projects would extend into future years and as planned, the cost for that work will be borne by the TUC O&M budget or, as appropriate, by the other Federal Gov't. sponsor of the project.

1.3 Highlights of Program Benefits

As stated in the Foreword, the objective of the Program was to permit the railway supplier and operating industries to produce and deploy equipment and systems which will yield improvements in rail freight productivity, capacity, safety and costs, and improve Canada's ability to compete in domestic and foreign markets. Improvements in each of these areas have been achieved. Some of the more significant of these are summarized in the following:

Railway Electrification

A series of projects were undertaken early in the Program to obtain better information on the technical problems and probable costs and benefits of railway electrification in Canada. Output from these projects greatly assisted B.C. Rail (BCR) in their decision to electrify their new 132 km Tumbler Ridge Branch Line and contributed significantly to the design and expeditious construction of the line, which is now in service - the only electrified rail freight line in Canada and one of only three in the world having a 50 kV 60 Hz power supply. Subsequently, the new 50 kV operation was extended southward on the BCR main line to Tacheeda, a distance of approximately 10 km from the junction with the branch line.

The decision to electrify the branch line at the time of construction resulted in major cost benefits to BCR through avoidance of the installation of tunnel ventilation and its annual maintenance. The transfer of European railway electrification technology and adaptation to Canadian requirements was successfully achieved in the areas of design and construction and the capability of Canadian industry to produce the necessary electrical components was demonstrated. General Motors, who supplied the electric locomotives consider that the contract with BCR should establish their Canadian division, based in London, Ontario, as the leading North American contender for this type of business.

The first full year of operation (8.5 MGT) of the electrified system following the break-in period, showed a net return in excess of 20% ($3.6M) on the total investment, including both the contributions to the construction cost made by Federal and Provincial governments and the benefits from the avoidance of tunnel ventilation construction and maintenance costs.

A further cost-shared study made by BCR, of electrifying their present main line operation between Tacheeda and Prince George (approximately 130 km), showed an annual rate of return of 6.8% at the present traffic level of 8.5 MGT annually, and 20.7% if traffic increases to 17 MGT per year.

Locomotive Fuel Saving System

Usual railway practice in the past has been to leave locomotives idling rather than shutting them down when not working. Increasing fuel costs have resulted in some reduction to this practice, but the reduction has been constrained because of the risk, at low temperatures, of engine freeze-up or inability to re-start.

The purpose of this project was the development of a control system, which, on the basis of pre-set temperatures, will automatically stop and start an idling locomotive engine, thereby achieving a significant reduction in total idling time and consequent reduction in fuel consumption without risk of engine damage or inability to re-start. The system is based on a pre-prototype unit, designed and built by the Quebec North Shore and Labrador Railway (QNS&L).

The work was carried out by DSL Dynamic Sciences Ltd. of Montreal, Quebec., under a contract awarded as a result of their Unsolicited Proposal. Five pre-production systems have been installed on QNS&L locomotives and that railway has placed an order to equip their entire locomotive fleet. On the basis of testing to date, a reduction in their annual total locomotive fuel cost in the order of 10% is expected.

Diesel Engine Research

A single cylinder research engine test facility is a basic requirement for cost-effective engine research. Such a facility was needed by Bombardier Rail and Diesel Products Division to assist in the research related to their new B-2400, and upgrading of their 251, medium speed diesel engines for railway and marine service. A survey revealed that a single cylinder engine, representative of their product type, was not available.

A shared-cost contract was entered into by TDC with Bombardier under the ARF Program, for the design and manufacture of two engines and necessary test cell. This work was successfully accomplished under project 4558/4840.

The facility has already proven to be of great value to Bombardier in their research work. Additionally, although sales of the test engine were not originally foreseen, two have already been sold and on the basis of inquiries made, the sale of as many as eight more is a possibility. The first engine was purchased by the National Research Council (NRC) and the second by the Association of American Railroads and installed at the Southwest Research Institute (SWRI) in San Antonio, Texas. A coordinated research

Diesel Engine Research (cont'd)

program between NRC, SWRI and Bombardier R&D addressing ceramic engine components research, lube evaluation, staged and pilot fuel injection and low cetane and off-specification fuels is under development. The program shows promise for achieving additional progress in engine research and development, with ultimate cost savings to industry.

Train Dynamics Simulation

Longitudinal dynamics play an important part in the behaviour of long trains, and the safe handling of such trains is based in large part on the knowledge of the train's behaviour in response to various features of the terrain in conjunction with the handling of throttle and braking systems. The objective of this project (4813) was to achieve for the first time, real-time simulation of these complex train handling problems using purely digital computing simulation techniques.

The simulation program provides the ability for the operator to determine dynamic longitudinal forces at couplers and the longitudinal acceleration of cars within the train. It models air brakes, locomotive systems, and effects due to rolling and curve resistances and grade. It also provides for non-real-time operation (slower than real-time) which allows for more detailed generation of results. The program has been configured in a form which allows for a broad range of flexibility, including user interaction, initiation of undesired conditions and malfunctions, and the ability to choose alternate track conditions during the run. The software program is in its testing phase. In the near future it will be installed on NRC facilities so special research studies may be conducted directed towards better train handling with consequent improved safety of operations and reductions in fuel consumption and track and equipment damage.

Due in part to the work done on this project, DSL Dynamic Sciences Limited (the contractor), was able to obtain a major contract with the Southern Pacific railroad to upgrade their locomotive simulator and subsequently to win an international competition to supply Swedish State Railways with a locomotive simulator.

Tank Car Thermal Modelling

As part of a dangerous goods tank car safety program, considerable effort was directed within the ARF Program to develop a computer model to simulate the response of a railway tank car, and its lading, to external fire impingement. The purpose of the model is to increase railway and public safety by enabling a study of the effectiveness of thermal protection systems for protecting against the risk of thermally induced tank rupture.

Tank Car Thermal Modelling (cont'd)

The early stages of the program were directed towards achieving a sound understanding of the process, with particular portions of the work being carried out by several contractors under separate contracts with TDC. Davis Engineering of Ottawa, Ontario, was one of the contractors and the current model was developed by that firm.

The computer model can simulate a rail tank-car, or any other long cylindrical tank, filled with a number of light petroleum products, such as propane and propylene. It can simulate both an engulfing type fire or a torch type fire. Tank roll and pitch can be accounted for.

The model can predict tank internal pressure, tank wall temperature distributions, mean lading temperatures, relief valve flow rates, liquid level, tank wall stress conditions, and tank failure, all as functions of time from fire ignition. It has been validated using available experimental data from full and fifth-scale fire tests conducted on tank-cars filled with propane.

Thermal protection systems that can presently be simulated include: thermal insulation, thermal radiation shielding, internal thermal protection, fusible plug pressure relief devices, and pressure relief valves. These systems can be modelled separately, or in any combination.

Details of the model have been requested by the Association of American Railroads and by a major North American chemical manufacturer, and the requested information supplied.

A number of TDC projects either on-going or in the planning stage will make use of the model in further research in the area of tank car safety.

Rail Metallurgy

Under one of the early projects in the ARF Program (4467), Queen's University, through the Canadian Institute of Guided Ground Transport, investigated alloys and heat treatments for improving the yield strength and wear resistance of austenitic-manganese steels used for special trackwork, such as frogs and cross-overs. Such improvements would contribute towards improved safety and reduced costs of railway operations.

The findings from this work were sufficiently promising to justify continued investigation, and a second phase of the project has been undertaken within the TDC budget under a cost-sharing agreement with CP Ltd. In addition to the railway funding, both the railway and a railway supplier firm are providing in-kind contributions in the form of expertise, materials, materials testing and in-track demonstration and assessments of castings of promising new alloys.

Track Maintenance

The annual cost of maintaining railway track in Canada exceeds $500 million. Various projects undertaken within the Program, supported by financial and/or in-kind contributions from CN Rail, CP Rail and VIA Rail, the Association of American Railroads and three different railway supplier firms, were aimed at reducing this figure and improving track safety. Other major participants included the Western Laboratory of the National Research Council in Vancouver, B.C., and the Canadian Institute of Guided Ground Transport of Kingston, Ont., to whom it was possible to provide financial assistance for their work on the projects through the ARFP funding.

A major accomplishment, the development and implementation of an improved rail head profile grinding method to control growth of corrugations in curved track and extend rail life, is expected to produce direct savings of more than $1 million annually on CP Rail alone.

Over the longer term, economies will also result from the ballast and subgrade research projects conducted within the program and directed towards gaining an improved understanding of ways and means to improve track support. Further benefits in the areas of cost reduction and improved safety will be derived through the implementation of computer models developed to enable quantitative predictions of track deterioration (and thus of specific future maintenance requirements), related to axle loadings and traffic levels.

End-of-Train Monitoring

Through projects 4924 and 6271, financial assistance was provided to Glenayre Electronics of Vancouver, B.C., towards their development of electronic equipment which automatically monitors trainline air pressure at rear-of-train and displays pressure readings in the locomotive cab. In the final stage of this development Glenayre was assisted by DSL Dynamic Sciences Ltd. of Montreal, Que.

Ownership and operating costs for cabooses on Canada's two major railways total more than $60 million per year, exclusive of crew costs. Whereas the present day replacement cost of a caboose in Canada is in the order of $175,000., the cost of the electronic equipment alternative is less than $5,000. There are approximately 1800 cabooses in the Canadian fleet and the substitution of the electronic equipment would thus result in major reductions in ownership costs. Substitution will also enable simultaneous application of emergency braking from both the front and rear of train. It has been shown that this will result, in many circumstances, in

End-of-Train Monitoring (cont'd)

much reduced in-train forces with consequent reduced possibility of equipment damage and/or derailment - both of which frequently result from emergency brake application. A major additional benefit is a reduction in stopping distance following emergency brake application, with obvious benefit.

Canadian railways have made application to the CTC for approval to use the equipment and meanwhile are evaluating it, using purchased equipment. The equipment developer has already obtained export orders in excess of $7 million from railways in the U.S.A., where deregulation has permitted more rapid implementation of the technology. This represents approximately 50% of the sales to date in the U.S.A. Experience there with the equipment has demonstrated that revisions to certain of the mandatory brake testing requirements can be made, resulting in additional reductions to railway operating costs.

Automatic Train Control

The joint Railway Association of Canada (RAC), Association of American Railroads (AAR), Automatic Train Control Systems (ATCS) project is designed to improve the economic, operational and safety performance of the North Amercian railway industry through the application of microelectronics to train movement control. The project is a cooperative effort by Canadian and U.S. railroads and to date, it has received no direct government funding in either country. Nevertheless, work supported through the Augmented Rail Freight R&D Program has contributed significantly towards its feasibility as noted below.

All but the simplest level of ATCS provides information on train location and speed, derived by interaction between uniquely encoded transponders, placed at selected locations on the track, and interrogation equipment on the train. With funding assistance from TDC prior to start of the ARF Program, such a transponder was developed by Glenayre Electronics of Vancouver, B.C. and BC Rail, and a small experimental train control system, known as the Location, Identification and Control (LIC) System was installed on that railway. With subsequent assistance under the ARF Program, a 42-mile main line test section on BC Rail was installed.

Certain deficiencies in the test section installation prevented putting it into operational service; nevertheless, many of the LIC components functioned satisfactorily and it is BC Rail's intention to continue development of the system in parallel with the RAC/AAR ATCS project. Important groundwork though, was accomplished as a result of the ARF Program.

2. FINAL QUARTERLY REPORT (4TH QUARTER FY 1985/86)

2.1 Accomplishments During the Quarter

- Final reports were received for 5 projects, bringing the total number of completed R&D projects to 64 out of a total of 87.

- The final report was received for a project for the laboratory testing of a prototype microprocessor-controlled train data recording system. (TP 7496E)

- On a project to provide support for laboratory and field testing of previously-developed prototype microprocessor-controlled train data recording systems, operating data were collected during runs made by CN snowplow 55614 on which an enhanced prototype recorder had been previously installed.

- A project for the preparation of CSA guidelines for railway electrification in Canada was completed. The final report for this project is the CSA publication C22-3 No. 8-M1986, Railway Electrification Guidelines.

- The final report was received for a project to evaluate the Canadian-developed Location, Identification and Control System (LICS) for train operation on an electrified railway line (BC Rail Tumbler Ridge Branch Line). (TP 7269E)

- The final report was received for a project to document the installation, commissioning and early operational phases of the electrified BC Rail Tumbler Ridge Branch Line. (TP 7625E)

- Preparation of draft final report was started for a project to construct a full scale half section of electrified railway catenary and measure the lateral deflection under specified wind and ice conditions.

- On a project to improve the capabilities of an existing (industrial) diesel engine test facility:

  - baseline testing of the 1-251 engine continued following shut-down for engine inspection;
  - piston cooling tests for the 1-B2400 engine were completed;
  - plumbing and electrical connections in the fuel/lubricant laboratory were made;
  - provincial approval was received for the combustor casing for the turbocharger rig.

- On a project to carry out a study of the future motive power requirements of Canadian railways and an evaluation of relevant technological developments, pertinent railway operational data were collected and its analysis commenced.

- On a project for development of hardware and software for a control system to automatically stop and start an idling locomotive engine on the basis of pre-set temperatures in order to reduce fuel consumption, testing of the prototype system on a locomotive in revenue service, was completed.

- On a project for development of a microprocessor-based electronic control package for an AC-DC locomotive, laboratory testing of the prototype hardware and software package continued. A draft report on the software development was received, reviewed and accepted.

- On a project to evaluate a new protection device for railway tank cars and other containers holding pressurized dangerous liquids, an analysis of the forces generated by the "sloshing" of the lading was completed and an analysis of the capability of the proposed suppression system to accommodate those dynamic forces was commenced.

- In connection with a project for the development of a real-time train dynamics simulation model:

  - transfer and conversion of existing software modules from the contractor's H.P. computer to a Vax computer was completed; (The computer at NRC where the model will be used, is a Vax).
  - the other hardware for the system was selected.

- The draft final report for a project for development of a frame-braced freight car truck was reviewed and returned to the contractor with comments.

- The final report was received for a project to promote the development of a new generation of freight trains (High Productivity Integral Train [HPIT]. (TP 7119E)

- The draft final report was received for a project to examine the feasibility of an intermodal rail freight service to accommodate low volume shippers.

- Work on the fourth and final phase of the project for development of a rail wear and fatigue model was completed, and preparation of the draft final report was started.

- On a project for the design and manufacture of a Wheel/Rail System Test Rig:

  - a preliminary analysis of the frame stiffness and vibration characteristics was completed;
  - long lead time material was ordered and certain other material was delivered;
  - the manufacture of certain other components was undertaken.

- On a project to acquire additional soil suction data at five field sites established under a previous project, acquisition of the data was completed and preparation of the draft final report on the work was commenced.

- On a project for the development of practical and cost-effective techniques to reduce track geometry and track component deterioration, the following reports were received:

  - final report on the subballast and geotextiles portions of work (TP 7383E);
  - interim report describing the status of the overall research program as of the end of the first year (TP 6024E);
  - interim report describing the status of the overall research program as of the end of the second year, and outlining the work plan for the final year (TP 7417E).

- The final report was received for a project to develop and validate a computer program for analysis of the stability of railway track structures (TP 7294E).

- On a project for the further development of an end-of-train monitoring system, in-train testing of the modified system was completed. Both major Canadian railways placed orders with the developer of the system for the hardware and software to enable continuance of testing on their own property in conformance with RTC requirements.

- On a project for the development and demonstration of an Advanced Train Control System (ATCS) on BC Rail:

  - major upgrading of the communications sub-system of the LIC train control system was completed;
  - a new set of computers was acquired and installed;
  - previously developed software for the system was upgraded.

- On a project for the development of a system to permit control of railway power switch machines from the locomotive in non-signalled territory:

  - the design concept was developed;
  - preliminary operating procedures were compiled and reviewed;
  - a presentation was made to CTC operating personnel;
  - the detailed design was completed and reviewed.

- The program status report as of December 31, 1986, was prepared.

2.2 Projects Added During the Quarter

There were 3 R&D projects added to the Program during the final quarter of FY 1985/86. The three new projects are described below. Data regarding funding for them and for the Program as a whole to date are summarized in Table 2, to be found following the descriptions. More detailed financial data are presented in Tables 3 to 7 inclusive and in the program element tables in Appendix 1.

Soil Suction Measurement Ph. 2 (Project #6508) The stiffness and stability of railway track subgrade for a particular soil is governed by the pore pressure within the soil. The pore pressure will be positive in a soil located below the water table and negative in a soil located above the water table. Since the upper portion of the subgrade is usually dry, negative pore pressures or "soil suction" is a primary design consideration in railway track foundations. Although it is known that tremendous changes in strength/stiffness can result from only a small percentage change in moisture content, the effect of these changes on the permanent deformation characteristics of fine grained soils has not been well defined.

A research program has been undertaken to determine the practicality of measuring soil suction in the field and applying the results to existing soil mechanics theory in order to increase the level of understanding of railway subgrade performance and slope stability. The first phase of this program carried out under project #6305 entailed the evaluation of techniques available for the measurement of soil suction with special emphasis on field measuring systems. Four sites in the Regina area and a fifth near Edmonton were established at each of which regular measurements of soil suction data were made. The cost of the work was shared equally between TDC, CP Rail and CN Rail.

The results from Phase I are positive and showed that matric suction can be measured insitu, but insufficient data were collected to firmly establish the relationship between the variation in soil suction and the changing micro-climatic conditions and provide confidence in the measuring system.

This second phase work involves the continued monitoring of the five established field sites to determine seasonal variations and develop confidence in the measuring system. An Agwatronics Inc. data acquisition system will be alternated between the four sites in the Regina area on a weekly basis while a calibrated portable suction meter will be utilized by CN to monitor the site near Edmonton. The data collected will be analyzed and related to environmental conditions and a report on the work will be generated.

A contract for the work has been awarded to Clifton Associates Ltd., Consulting Geotechnical Engineers, who was the contractor for Phase I. Each of the two railways will, as they did in Phase I, contract separately with Clifton Associates for their one-third share of the contract cost and also provide "in-kind" contributions associated with the field site installation and monitoring.

The work is expected to be completed by the end of FY 1985/86.

Project Participants:

Clifton Associates Ltd.	- Contractor
CP Rail	- Sponsor
CN Rail	- Sponsor
TDC	- Sponsor and Project Manager

Railway Radio Operated Power Switch Machine Control System Development: Short Title: "Railway Radio Opp Power Switch (Project #6628)
The objective of this project is to increase the safety and productivity of Railway operations by the development of a system which will permit control of railway power switch machines by radio from the locomotive in non-signaled territory. The project stems out of an unsolicited proposal submitted to DSS by Signalcom Canada Corporation.

North American railways utilize voice radio to control train routing in territories where traffic density cannot justify the expense of traditional centralized traffic control (CTC) signalling. Lines under voice radio control are commonly referred to as Manual Block System (MBS) territory. In MBS territory, a central office dispatcher sends track occupancy authorities on voice radio directly to the train crews, who then repeat the instructions to the dispatcher for verification. Train position is also reported by the crews by means of voice radio. Routing instructions are determined by the dispatcher based upon safety rules established for each line.

MBS procedures usually call for switches to be set in the normal (mainline) position, with manual operation (by the train crew) to reverse in order to take a siding, and then manual operation to return the switch to normal after the train has cleared the switch. These procedures necessitate two stops of the train - once before entering the siding and a second time after leaving the siding.

The development of a successful radio operated power switch will reduce the numbers of train stops with resultant savings in fuel and wear. Line capacity will be increased, safety enhaced and cabooseless operation in MBS territories facilitated.

The overall development is expected to span over three phases of work as follows:

- Phase I - Design and Prototype
- Phase II - Field Testing
- Phase III - Demonstration and Assessment.

This project is limited to Phase I activities only.

A contract for the Phase I work was awarded to Signalcom Canada Corporation in January 1986. CP Rail have agreed to review the operating rules developed by Signalcom relative to use and operation of the switch.

The work is expected to be completed on or before September 1, 1986.

Project Participants:

Signalcom Canada Corporation	- Contractor
CP Rail	- Sponsor
TDC	- Sponsor and Project Manager

Advanced Train Control System Test Bed - System Development: Short Title: "ATCS Test Bed Development (Project #6622/6623) The objective of this project is to increase the safety and productivity of railway operations by the development and demonstration of an Advanced Train Control System (ATCS) on BC Rail. The system is to have the ability to perform in two operating environments - Manual Block System (MBS) territory using BC Rail's Squamish subdivision and electrified territory using the railway's Tumbler Ridge subdivision.

The project stems out of the work carried out by BC Rail under contract with TDC and titled "Location, Identification and Control - Operational Evaluation of Train Control and Dispatcher Assist Functions". Past worked proved that the concept and the prototype system are suitable for implementation, while identifying problems and yielding a number of technical recommendations regarding improvements in the capacity and reliability of the developed prototype. The activities carried out by BC Rail in this area under contract with TDC were a major factor in the recent decision by RAC and later by AAR to join efforts in a common ATCS project. The engineering consultant to the common project - ARINC - is in direct communications with BC Rail and the technical input from BCR's past and present work is expected to play an important role in the final recommendations prepared by ARINC for adoption by RAC/AAR.

In addition to yielding a functionally acceptable data communications system between the railway's dispatch centre and the trains, the project will provide a "test bed", in Canada, on which various ATCS concepts and products can be tested.

The work will include:

- preparation of detailed system specifications;
- purchase and installation of the host computer;
- detailed design of the system;
- implementation of the system;
- shop and on-site testing;
- demonstration of the system on the Squamish and Tumbler Ridge subdivision
- preparation of technical reports on the work carried out and the results achieved.

A contract for the work has been awarded to BC Rail. Approximately 47% of the total cost of the project will be borne by TDC and the balance by BC Rail. The work is expected to be completed by the end of August 1987.

Project Participants:

BC Rail	- Sponsor and Contractor
Systek Engineering	- Sub-contractor
NK Systems Ltd.	- Sub-contractor
TDC	- Sponsor and Project Manager

TABLE 2

SUMMARY OF FUNDING AND RESOURCE CONTRIBUTIONS FOR PROJECTS ACTIVATED TO END 4TH QUARTER FY 1985/1986 (MARCH 31, 1986)

($000)

TITLE	TDC PROJECT NO.	TOTAL AUTHORIZED		
		ARFP	INDUSTRY	OTHER
ACTIVATED PRIOR TO 4TH QUARTER		9538.1	3245.5	3125.5
ADJUSTMENTS DURING 4TH QUARTER TO PROJECTS ACTIVATED PRIOR TO START OF 4TH QUARTER (TABLE 3)		26.9	(171.1)	140.0
Subtotal		9565.0	3074.4	3265.5
ADDED DURING 4TH QUARTER				
Soil Suction Measurement Ph 2	6508	15.3	26.9	--
ATCS Test Bed Development	6622/23	82.6	290.0	137.4
Rly. Radio Oper. Power Switch	6628	98.5	25.0	--
TOTAL		9761.4(1)	3416.3(2)	3402.9(3)

(1) Table 7

(2) 2727.2 Resource Contribution; 689.1 Financial Contribution (Table 5)

(3) 499.9 DSS Bridge
1429.3 Energy R&D
1003.5 TDC O&M
2932.7 Sub-Total Other Federal Funds (Table 7 Footnote 2)
373.1 NRC Resource Contribution (Table 4)
97.1 Province of Ontario (Table 6)
3402.9

TABLE 3

ADJUSTMENTS DURING 4th QUARTER TO FUNDING FOR PROJECTS ACTIVATED PRIOR TO START OF 4th QUARTER

($000)

TITLE	TDC PROJECT NUMBER	REDUCTION () OR INCREASE TO FUNDING AUTHORIZATION			OTHER SPONSOR
		ARFP	INDUSTRY	OTHER	
Wheel/Rail Interaction Study	6389	--	--	140.0	TDC O&M
BC Rail Elect'n LICS	4908/09	--	(38.4)	--	
Radial Axle Truck Testing	6132	--	(28.0)	--	
Tank Explosion Suppression	6476	--	--	37.5	TDC O&M
Tank Explosion Suppression	6477	--	--	(37.5)	DSS
HI Productivity Integral Train	6340	(0.3)	--	--	
Convoy Canada Demonstration	4942	27.2	--	--	
Track Structure Research	6059	--	(28.3)	--	
Automatic Rail Car Ident'n.	4436/37	--	(76.4)	--	
NET CHANGE		26.9	(171.1)	140.0	

TABLE 4

NRC RESOURCE AUTHORIZATIONS & EXPENDITURES
AS OF END 4TH QUARTER FY 1985/86 (MARCH 31, 1986)

($000)

PROJECT TITLE	TDC PROJECT NO.	AUTHORIZATIONS	EXPENDITURES*	
			DURING 4TH QUARTER FY 1985/86	TOTAL TO MARCH 31, 1986 INCL. PREV. YEARS
Program Element No. 4				
Rail Wear & Fatigue Model (C)	4522	60.0	0.0	60.0
Rail Wear & Fatigue Model (C) Phase 2	4830	120.0	0.0	120.0
Rail Wear & Fatigue Phase 3	6155	65.0	0.0	65.0
Rail Wear & Fatigue Phase 4	6433	100.0	25.0	100.0
Rly Switch Operable in Snow and Ice (C)	4575	12.7	12.7	12.7
Test Instrumentation Rail Grinding (C)	4721	15.4	0.0	15.4
TOTAL		373.1	25.0	373.1

*Based on a nominal value of $50,000 for each person-year.

(C) Completed

TABLE 5

INDUSTRY AUTHORIZATIONS & EXPENDITURES
AS OF MARCH 31, 1986

($000)

PROJECT TITLE		TDC PROJECT NO.	AUTHORIZATIONS			EXPENDITURES		
			Resource	Financial	Total	Prev. Yrs.	FY 85/86	Total
Program Element No. 1								
Train Data Recording System	(C)	4983/4462/63	37.0		37.0	37.0	0.0	37.0
TDRS Engineering Support		6306/07	73.0		73.0	23.0	50.0	73.0
BC Rail Catenary Mfg. Drawings	(C)	4933	174.0		174.0	174.4	0.0	174.4
BC Rail Elect'n. LICS	(C)	4908/09		43.8	43.8	0.0	43.8	43.8
BC Rail Elect'n.-Loco Testing	(C)	6032/33	100.0		100.0	100.0	0.0	100.0
Elect. Tacheeda-Prince George	(C)	6408	5.0		5.0	0.0	5.0	5.0
BC Rail Elect'n.-System Docum.	(C)	4960/61	50.0		50.0	50.0	0.0	50.0
Two Axle Loco. Steerable Truck	(C)	4715	64.6		64.6	64.6	0.0	64.6
Radar Speedometer Eval.	(C)	4530	30.0		30.0	23.0	7.0	30.0
Diesel Combustion	(C)	4558/4840	219.8		219.8	219.8	0.0	219.8
Laboratory Diesel Engine Ph.3		6303/04	120.0		120.0	29.5	70.9	100.4
Shunter Loco Design	(C)	4588	63.3		63.3	63.3	0.0	63.3
Microprocessor AC Loco.		4560	251.9		251.9	163.7	8.2	171.9
Wheel/Rail Interaction Study		6390	20.0		20.0	20.0	0.0	20.0
SUB-TOTAL			1208.6	43.8	1252.4	968.3	184.9	1153.2
Program Element No. 2								
Radial Axle Truck Testing	(C)	6132	103.0		103.0	94.3	8.7	103.0
Program Element No. 3								
Intermodal Term. Simulation	(C)	4905/4604	284.4		284.4	284.4	0.0	284.4
Program Element No. 4								
Austenitic Managese Steel	(C)	4467		29.8	29.8	29.8	0.0	29.8
Rly Switch Oper. in Snow & Ice	(C)	4575	27.0		27.0	27.0	0.0	27.0
Rail Grinding Optimization	(C)	4562	112.2		112.2	112.2	0.0	112.2
Snowmaster-Conceptual Design	(C)	6038	10.0		10.0	10.0	0.0	10.0
Rail Profile Grinding - Ph. 2	(C)	6011	80.0	40.0	120.0	120.0	0.0	120.0
TDC/CP Research 1984	(C)	6138	192.0		192.0	191.4	0.6	192.0
Induction Track Hardening	(C)	6136	12.0		12.0	12.0	0.0	12.0
Soil Suction Measurement	(C)	6305	10.0	60.0	70.0	62.0	8.0	70.0
Soil Suction Measurement Ph. 2		6508		26.9	26.9	0.0	26.9	26.9
Track Structure Research		6059	110.0	216.7	326.7	90.0	196.7	286.7
SUB-TOTAL			553.2	373.4	926.6	654.4	232.2	886.6
Program Element No. 5								
On-Board Hot Box Detectors	(C)	4508/4835		66.7	66.7	66.7	0.0	66.7
Automatic Rail Car Ident.		4436/37	157.6		157.6	157.6	0.0	157.6
End-of-Train Monitoring	(C)	4924	87.0		87.0	87.0	0.0	87.0
Further Dev. E-O-T Monitoring		6271	138.7		138.7	87.0	52.1	139.1
Lampchanger for Rly Signal	(C)	4812	20.0		20.0	20.0	0.0	20.0
Railway Colour Light Signal	(C)	4980	28.0		28.0	28.0	0.0	28.0
Railway Colour Light Signal-2	(C)	6292	13.7		13.7	13.0	0.7	13.7
Signal Trans Tech Freight Train	(C)	6053		23.2	23.2	23.2	0.0	23.2
ATCS Test Bed Development		6622/23	108.0	182.0	290.0	0.0	290.0	290.0
Rly Radio Oper. Power Switch		6628	25.0		25.0	0.0	12.5	12.5
SUB-TOTAL			578.0	271.9	849.9	482.5	355.3	837.8
TOTAL			2727.2	689.1	3416.3	2483.9(1)	781.1(2)	3265.0(3)

(C) Completed
(1) 2234.7 Resource Contribution; 249.2 Financial Contribution
(2) 371.2 Resource Contribution; 409.9 Financial Contribution
(3) 2605.9 Resource Contribution; 659.1 Financial Contribution

TABLE 6

PROVINCE OF ONTARIO AUTHORIZATIONS & EXPENDITURES
AS OF March 31, 1986

($000)

PROJECT TITLE	TDC PROJECT NO.	AUTHORI-ZATIONS	EXPENDITURES		
			Previous Years	FY 1985/86	Total
Frame Braced Freight Car Truck	4729	97.1	97.1	0.0	97.1
TOTAL		97.1	97.1	0.0	97.1

TABLE 7

ARF PROGRAM FINANCIAL SUMMARY

($000)

PROGRAM ELEMENT	AUTHORIZED					TOTAL OF PREVIOUS		
	ARFP	OTHER FEDERAL*		INDUSTRY		ARFP	OTHER FEDERAL*	
	$	$	RESOURCE	$	RESOURCE	$	$	RESOURCE
1. MOTIVE POWER	3995.0	1897.4	0.0	43.8	1208.6	2950.9	1111.6	0.0
2. FREIGHT CARS	1314.3	557.7(1)	0.0	0.0	103.0	916.3	442.6(3)	0.0
3. INTERMODAL	354.3	43.0	0.0	0.0	284.4	291.1	43.0	0.0
4. INFRASTRUCTURE AND MAINTENANCE	1659.6	109.1	373.1	373.4	553.2	1092.2	109.1	273.1
5. COMMUNICATION AND AUTOMATION	1785.9	397.8	0.0	271.9	578.0	1368.8	260.4	0.0
6. PROGRAM SUPPORT	652.3	24.8	0.0	0.0	0.0	358.0	0.0	0.0
TOTAL $	9761.4 (Note A)	3029.8(2)		689.1		6977.3	1966.7(4)	
TOTAL RESOURCES			373.1		2727.2			273.1
TOTAL PROGRAM	16580.6					11701.0		

*Except as noted below:
(1) Federal Govt. 460.6 Prov. of Ont. 97.1 Proj. 4729
(2) Federal Govt. 2932.7 Prov. of Ont. 97.1 Proj. 4729
(3) Federal Govt. 345.5 Prov. of Ont. 97.1 Proj. 4729
(4) Federal Govt. 1869.6 Prov. of Ont. 97.1 Proj. 4729
(5) Federal Govt. 383.6 Prov. of Ont. 97.1 Proj. 4729
(6) Federal Govt. 2402.0 Prov. of Ont. 97.1 Proj. 4729

NOTE A

Project schedules and budgets were planned to result in disbursement of the total ARFP budget of $9M by the end of FY 1985/86. It was known that work on certain projects would extend into future years and, as planned, the cost for that work will be borne by the TDC O&M budget or, as appropriate, by the other Federal Govt. sponsor of the project.

TABLE 7

INANCIAL SUMMARY AS OF MARCH 31, 1986

($000)

TAL OF PREVIOUS YEARS				DISBURSEMENTS/RESOURCE INPUT FY 1985/86					TOTAL TO MARCH 31, 1986				
THER FEDERAL*	RESOURCE	INDUSTRY $	RESOURCE	ARFP $	OTHER FEDERAL* $	RESOURCE	INDUSTRY $	RESOURCE	ARFP $	OTHER FEDERAL* $	RESOURCE	INDUSTRY $	RESOURCE
.6	0.0	0.0	968.3	815.0	494.3	0.0	43.8	141.1	3765.9	1605.9	0.0	43.8	1109.4
.6(3)	0.0	0.0	94.3	271.0	38.1	0.0	0.0	8.7	1187.3	480.7(5)	0.0	0.0	103.0
.0	0.0	0.0	284.4	63.2	0.0	0.0	0.0	0.0	354.3	43.0	0.0	0.0	284.4
.1	273.1	159.3	495.1	191.4	0.0	100.0	184.1	48.1	1283.6	109.1	373.1	343.4	543.2
.4	0.0	89.9	392.6	263.4	0.0	0.0	182.0	173.3	1632.2	260.4	0.0	271.9	565.9
0	0.0	0.0	0.0	111.8	0.0	0.0	0.0	0.0	469.8	0.0	0.0	0.0	0.0
7(4)		249.2		1715.8	532.4		409.9		8693.1	2499.1(6)		659.1	
	273.1		2234.7			100.0		371.2			373.1		2605.9
11701.0				3129.3					14830.3				

Proj. 4729
Proj. 4729
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APPENDIX 1

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS
AS OF MARCH 31, 1986

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS ($000)
AS OF MARCH 31, 1986

PROGRAM ELEMENT NO. 1 - MOTIVE POWER

TITLE		TDC PROJECT NUMBER	TOTAL AUTHORIZED			ACTUAL DISBURSEMENTS During 4th Quarter FY 85/86 (Jan.1 - March 31, 1986)			ACTUAL DISBURSEMENTS Total For FY 1985/86			ACTUAL DISBURSEMENTS Total to End FY 1985/1986(6) (March 31, 1986)		
			ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL
Train Data Recording Systems	(C)	4983	152.8	--	152.8	0.0	--	0.0	0.0	--	0.0	152.8	--	152.8
Train Data Recording Systems	(C)	4462	--	91.4(2)	91.4	--	0.0	0.0	--	0.0	0.0	--	91.4(2)	91.4
Train Data Recording Systems	(C)	4463	--	131.3(4)	131.3	--	0.0	0.0	--	0.0	0.0	--	131.3(4)	131.3
Lab.Eval. of Train Data Rec. System		4800	34.8	--	34.8	9.7	--	9.7	9.7	--	9.7	31.1	--	31.1
TDRS Lab & Field Test Support	(C)	6109	33.0	10.8(3)	43.8	[1.2]	0.0	[1.2]	[1.2]	0.0	[1.2]	31.8	10.8(3)	42.6
TDRS Engineering Support		6306	54.1	--	54.1	5.0	--	5.0	27.0	--	27.0	44.1	--	44.1
TDRS Engineering Support		6307	--	30.0(2)	30.0	--	0.0	0.0	--	0.0	0.0	--	30.0(2)	30.0
RAILWAY ELECTRIFICATION DEMONSTRATION														
Rlwy Elect'n Demo. - Eng. Study	(C)	4260	198.7	--	198.7	0.0	--	0.0	0.0	--	0.0	198.7	--	198.7
Rlwy Elect'n Demo. - Eng. Study	(C)	4267	--	50.0(1)	50.0	--	0.0	0.0	--	0.0	0.0	--	50.0(1)	50.0
Pusher Oper'ns. Train Simulation Study	(C)	4723	10.0	--	10.0	0.0	--	0.0	0.0	--	0.0	10.0	--	10.0
Rlwy Elect'n. Demo. - Signal Design	(C)	4585	15.0	--	15.0	0.0	--	0.0	0.0	--	0.0	15.0	--	15.0
Rlwy Elect'n. Demo. - Mast Tests	(C)	4586	30.0	--	30.0	0.0	--	0.0	0.0	--	0.0	29.9	--	29.9
Coal Line BCR - Elect'n. Study	(C)	4587	30.0	--	30.0	0.0	--	0.0	0.0	--	0.0	30.0	--	30.0
Coal Line BCR - Opern's. Analysis	(C)	4720	10.0	--	10.0	0.0	--	0.0	0.0	--	0.0	10.0	--	10.0
Assembly of Elect'n. Standards	(C)	4713	30.0	--	30.0	0.0	--	0.0	0.0	--	0.0	30.0	--	30.0
Study of Stds. for Rly. Elect'n. in Canada	(C)	4523	--	14.8(2)	14.8	--	0.0	0.0	--	0.0	0.0	--	14.8(2)	14.8
Drafting of Elect'n. Standards	(C)	6007	30.0	--	30.0	0.0	--	0.0	0.0	--	0.0	30.0	--	30.0
Rail Elect'n. Guidelines	(C)	6309	25.0	--	25.0	15.1	--	15.1	15.1	--	15.1	25.0	--	25.0
B.C. Rail Elect'n. - Substation	(C)	4786	255.8	--	255.8	0.0	--	0.0	0.0	--	0.0	255.8	--	255.8
B.C. Rail Elect'n. - Catenary Test	(C)	4785	173.5	276.5(3)	450.0	0.0	0.0	0.0	0.0	0.0	0.0	173.5	276.5(3)	450.0
B.C. Rail Elect'n. - Catenary Manuf. Dwgs.	(C)	4933	35.0	70.0(3)	105.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0	70.0(3)	105.0
Rail Elect'n. Demo - Catenary Study	(C)	4760	--	200.0(2)	200.0	--	0.0	0.0	--	0.0	0.0	--	200.0(2)	200.0
Testing Catenary Masts for Rlwy Elect'n.	(C)	4887	8.5	--	8.5	0.0	--	0.0	0.0	--	0.0	8.5	--	8.5
BC Rail Elect'n. LICS	(C)	4908	100.0	--	100.0	14.3	--	14.3	100.0	--	100.0	100.0	--	100.0
BC Rail Elect'n. LICS	(C)	4909	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0
BC Rail Elect'n. - Locomotive Testing	(C)	6032	125.0	--	125.0	0.0	--	0.0	0.0	--	0.0	125.0	--	125.0
BC Rail Elect'n. - Locomotive Testing	(C)	6033	175.0	--	175.0	0.0	--	0.0	0.0	--	0.0	175.0	--	175.0
BC Rail Elect'n. - System Documentation		4960	373.4	--	373.4	125.0	--	125.0	125.0	--	125.0	371.4	--	371.4
BC Rail Elect'n. - System Documentation		4961	33.0	103.6(3)	136.6	0.0	0.0	0.0	0.0	0.0	0.0	33.0	103.6(3)	136.6
Elect. Tacheeda - Prince George	(C)	6408	44.8	--	44.8	44.8	--	44.8	44.8	--	44.8	44.8	--	44.8
Electric Locomotive Sway	(C)	6165	9.3	--	9.3	0.0	--	0.0	0.0	--	0.0	9.3	--	9.3
Catenary Deflection		6313	187.0	--	187.0	75.4	--	75.4	148.8	--	148.8	148.8	--	148.8
Energy Storage for Rlwy Elect'n.	(C)	4458	46.9	--	46.9	0.0	--	0.0	0.0	--	0.0	46.9	--	46.9
STEERABLE LOCOMOTIVE TRUCKS														
Two-Axle Locomotive Steerable Truck	(C)	4715	320.0	--	320.0	0.0	--	0.0	0.0	--	0.0	320.0	--	320.0
Eval. for Two-Axle Loco. Steerable Truck	(C)	4717	30.0	--	30.0	0.0	--	0.0	0.0	--	0.0	30.0	--	30.0
Radar Speedometer Evaluation	(C)	4530	40.0	--	40.0	0.0	--	0.0	0.0	--	0.0	37.6	--	37.6
Diesel Combustion	(C)	4558	285.5	--	285.5	0.0	--	0.0	0.0	--	0.0	285.5	--	285.5
Diesel Combustion	(C)	4840	--	100.0(2)	100.0	--	0.0	0.0	--	0.0	0.0	--	100.0(2)	100.0
Laboratory Diesel Engine Ph.3		6303	289.9	--	289.9	8.4	--	8.4	135.0	--	135.0	289.9	--	289.9
Laboratory Diesel Engine Ph.3		6304	--	340.1(5)	340.1	--	185.8(5)	185.8	--	237.0(5)	237.0	--	237.0(5)	237.0
Railway Motive Power Dev. Study		6562	112.5	--	112.5	21.5	--	21.5	21.5	--	21.5	21.5	--	21.5
Railway Motive Power Dev. Study		6563	--	112.5(2)	112.5	--	21.5(2)	21.5	--	21.5(2)	21.5	--	21.5(2)	21.5
Locomotive Fuel Saving System		6314	115.0	--	115.0	0.0	--	0.0	115.0	--	115.0	115.0	--	115.0
Locomotive Fuel Saving System		6315	--	126.4(4)	126.4	--	0.0	0.0	--	100.0(4)	100.0	--	126.4(4)	126.4
Locomotive Fuel Saving System		6316	--	100.0(2)	100.0	--	44.5(2)	44.5	--	100.0(2)	100.0	--	100.0(2)	100.0
Shunter Loc. Design	(C)	4588	59.6	--	59.6	0.0	--	0.0	0.0	--	0.0	59.6	--	59.6
Microprocessor Altern. Current (AC) Loco.		4560	481.9	--	481.9	30.5	--	30.5	34.8	--	34.8	401.9	--	401.9
Wheel/Rail Interaction Study		6389	--	140.0(3)	140.0	--	35.8(3)	35.8	--	35.8(3)	35.8	--	42.6(3)	42.6
Wheel/Rail Interaction Study		6390	40.0	--	40.0	34.0	--	34.0	39.5	--	39.5	39.5	--	39.5
TOTAL MOTIVE POWER			3995.0	1897.4	5892.4	382.5	287.6	670.1	815.0	494.3	1309.3	3765.9	1605.9	5371.8

(C) Completed
(1) ER&D - Trn.
(2) NEP - Cons
(3) TDC O&M
(4) DSS Bridge Funding
(5) NEP Liqs
(6) Including Previous Years
[ ] Reduction

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS ($000)
AS OF MARCH 31, 1986

PROGRAM ELEMENT NO. 2 - FREIGHT CARS

TITLE		TDC PROJECT NUMBER	TOTAL AUTHORIZED			ACTUAL DISBURSEMENTS During 4th Quarter FY 85/86 (Jan. 1 - March 31, 1986)			Total For FY 1985/86			Total to End FY 1985/1986(5) (March 31, 1986)		
			ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL
TANK CAR EXPLOSION PROTECTION - PHASE II														
Tank Car Thermal Modelling	(C)	4468	18.0	4.1(1)	22.1	0.0	0.0	0.0	0.0	0.0	0.0	18.0	4.1(1)	22.1
Tank Car Thermal Modelling	(C)	4836	--	18.0(2)	18.0	--	0.0	0.0	--	0.0	0.0	--	18.0(2)	18.0
Tank Car Thermal Modelling	(C)	4559	23.5	--	23.5	0.0	--	0.0	0.0	--	0.0	23.5	--	23.5
Tank Car Thermal Modelling	(C)	4837	--	17.0(3)	17.0	--	0.0	0.0	--	0.0	0.0	--	17.0(3)	17.0
Thermal Modelling Evaluation	(C)	4710	3.0	--	3.0	0.0	--	0.0	0.0	--	0.0	2.9	--	2.9
Thermal Modelling Evaluation	(C)	4838	--	3.0(3)	3.0	--	0.0	0.0	--	0.0	0.0	--	3.0(3)	3.0
Thermal Modelling Evaluation	(C)	4728	3.0	--	3.0	0.0	--	0.0	0.0	--	0.0	2.9	--	2.9
Thermal Modelling Evaluation	(C)	4839	--	3.0(3)	3.0	--	0.0	0.0	--	0.0	0.0	--	3.0(3)	3.0
Tank Car Thermal Computer Model	(C)	4917	--	80.1(3)	80.1	--	0.0	0.0	--	0.0	0.0	--	80.1(3)	80.1
Tank Car Thermal Computer Model	(C)	4918	43.1	--	43.1	0.0	--	0.0	0.0	--	0.0	43.1	--	43.1
EXPLOSAFE Installation Design	(C)	4982	37.4	--	37.4	0.0	--	0.0	0.0	--	0.0	37.4	--	37.4
EXPLOSAFE Installation Design	(C)	4576	--	37.0(3)	37.0	--	0.0	0.0	--	0.0	0.0	--	37.0(3)	37.0
UNB Tank Car Study	(C)	4727	--	171.4(3)	171.4	--	0.0	0.0	--	0.0	0.0	--	171.4(3)	171.4
Tank Explosion Suppression		6475	81.0	--	81.0	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0
Tank Explosion Suppression		6476	--	65.0(1)	65.0	--	0.0	0.0	--	0.0	0.0	--	0.0	0.0
Tank Explosion Suppression		6477	--	50.0(4)	50.0	--	38.1(4)	38.1	--	38.1	38.1	--	38.1(4)	38.1
Train Control Scheme Development	(C)	4471	132.2	--	132.2	0.0	--	0.0	0.0	--	0.0	132.2	--	132.2
Train Dynamics Simulation		4813	376.6	--	376.6	71.5	--	71.5	83.5	--	83.5	360.5	--	360.5
Frame Braced Freight Car Truck		4729	104.0	--	104.0	0.0	--	0.0	0.0	--	0.0	104.0	--	104.0
Radial Axle Truck Testing Ph. 2	(C)	6132	119.0	12.0(1)	131.0	0.0	0.0	0.0	8.7	0.0	8.7	91.0	12.0(1)	103.0
HI Productivity Integral Train		6340	373.5	--	373.5	21.8	--	21.8	178.8	--	178.8	371.8	--	371.8
TOTAL FREIGHT CARS			1314.3	460.6	1774.9	93.3	38.1	131.4	271.0	38.1	309.1	1187.3	383.7	1571.0

(C) Completed
(1) TDC O&M
(2) ER&D - Trn.
(3) NEP - Trns.
(4) DSS Bridge Funding
(5) Including Previous Years

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS ($000)
AS OF MARCH 31, 1986

PROGRAM ELEMENT NO. 3 - INTERMODAL

TITLE	TDC PROJECT NUMBER	TOTAL AUTHORIZED			ACTUAL DISBURSEMENTS During 4th Quarter FY 85/86 (Jan.1 - March 31, 1986)			ACTUAL DISBURSEMENTS Total For FY 1985/86			ACTUAL DISBURSEMENTS Total to End FY 1985/1986(2) (March 31, 1986)		
		ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL
Intermodal Terminal Simulation (C)	4905	124.4	--	124.4	0.0	--	0.0	0.0	--	0.0	124.4	--	124.4
Intermodal Terminal Simulation (C)	4604	--	43.0(1)	43.0	--	0.0	0.0	--	0.0	0.0	--	43.0(1)	43.0
Convoy Canada Demonstation	4942	229.9	--	229.9	63.2	--	63.2	63.2	--	63.2	229.9	--	229.9
TOTAL INTERMODAL		354.3	43.0	397.3	63.2	0.0	63.2	63.2	0.0	63.2	354.3	43.0	397.3

(C) Completed

(1) NEP - Cons
(2) Including Previous Years

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS ($000)
AS OF MARCH 31, 1986

PROGRAM ELEMENT NO. 4 - INFRASTRUCTURE AND MAINTENANCE

TITLE	TDC PROJECT NUMBER	TOTAL AUTHORIZED			ACTUAL DISBURSEMENTS During 4th Quarter FY 85/86 (Jan.1 - March 31, 1986)			ACTUAL DISBURSEMENTS Total For FY 1985/86			ACTUAL DISBURSEMENTS Total to End FY 1985/1986(11) (March 31, 1986)		
		ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL
Controlled Climate Facility II (C)	4089	173.7	--	173.7	0.0	--	0.0	0.0	--	0.0	173.7	--	173.7
Austenitic Manganese Steel (C)	4467	88.3	--	88.3	0.0	--	0.0	0.0	--	0.0	88.3	--	88.3(1)
Rail Wear and Fatigue Model (C)	4522	29.1	17.3(2)	46.4(3)	0.0	0.0	0.0	0.0	0.0	0.0	29.1	17.3(2)	46.4(3)
Rail Wear and Fatigue Model Phase 2 (C)	4830	85.0	--	85.0(4)	0.0	--	0.0	0.0	--	0.0	84.9	--	84.9(4)
Rail Wear and Fatigue Model Phase 3 (C)	6155	50.0	15.0(2)	65.0(5)	0.0	0.0	0.0	23.5	0.0	23.5	42.3	15.0(2)	57.3(5)
Rail Wear and Fatigue Model Phase 4	6433	40.0	--	40.0(9)	8.0	--	8.0	39.3	--	39.3	39.3	--	39.3(9)
Rail Wear Model Enhancement (C)	4570	15.0	--	15.0	0.0	--	0.0	0.0	--	0.0	15.0	--	15.0
Rlwy. Switch Operable in Snow and Ice (C)	4575	98.9	--	98.9(6)	0.0	--	0.0	0.0	--	0.0	98.9	--	98.9(6)
Snow Master Conceptual Design (C)	6038	64.0	--	64.0	0.0	--	0.0	0.0	--	0.0	64.0	--	64.0
RAIL CORRUGATION STUDY													
Rail Grinding Optimization (C)	4562	60.0	--	60.0	0.0	--	0.0	0.0	--	0.0	60.0	0.0	60.0
Test Instrumentation-Rail Grinding (C)	4721	18.0	--	18.0(7)	0.0	--	0.0	0.0	--	0.0	15.1	--	15.1(7)
Rail Profile Grinding - Phase 2 (C)	6011	60.0	--	60.0	0.0	--	0.0	0.0	--	0.0	60.0	--	60.0
Wheel/Rail Bearing and Brake Test Rig (C)	4722	15.0	--	15.0	0.0	--	0.0	0.0	--	0.0	15.0	--	15.0
Wheel/Rail System Test Rig	6484	300.0	--	300.0	5.8	--	5.8	5.8	--	5.8	5.8	--	5.8
TDC/CP Research Program 1984 (C)	6138	167.0	25.0(2)	192.0	0.0	0.0	0.0	0.6	0.0	0.6	167.0	25.0(2)	192.0
Induction Track Hardening (C)	6136	20.0	--	20.0	0.0	--	0.0	4.2	--	4.2	20.0	--	20.0
Induction Track Hardening (C)	6137	--	22.2(8)	22.2	--	0.0	0.0	--	0.0	0.0	--	22.2(8)	22.2
TBM Evaluation (C)	6125	28.9	--	28.9	0.0	--	0.0	0.0	--	0.0	28.9	--	28.9
Soil Suction Measurement (C)	6305	30.0	--	30.0	0.0	--	0.0	0.0	--	0.0	30.0	--	30.0
Soil Suction Measurement Phase 2	6508	15.3	--	15.3	13.8	--	13.8	13.8	--	13.8	13.8	--	13.8
Track Structure Research	6059	227.2	17.8(2)	245.0	23.7(10)	0.0	23.7(10)	78.0(10)	0.0	78.0(10)	158.3	17.8(2)	176.1(10)
Computer Analysis of Rly Tracks	6012	74.2	11.8(2)	86.0	12.7	0.0	12.7	26.2	0.0	26.2	74.2	11.8(2)	86.0
TOTAL INFRASTRUCTURE AND MAINTENANCE		1659.6	109.1	1768.7	64.0	0.0	64.0	191.4	0.0	191.4	1283.6	109.1	1392.7

(C) Completed
(1) Includes credit of 29.8 for financial contribution received from Industry (Project #4781)
(2) TDC O&M
(3) NRC Resource Contribution of 60.0 not included
(4) NRC Resource Contribution of 120.0 not included
(5) NRC Resource Contribution of 65.0 not included
(6) NRC Resource Contribution of 12.7 not included
(7) NRC Resource Contribution of 15.4 not included
(8) DSS
(9) NRC Resource Contribution of 100.0 not included
(10) Includes credit of 15.0 for financial contribution received from Industry (Project #4906)
(11) Including Previous Years

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS ($000)
AS OF MARCH 31, 1986

PROGRAM ELEMENT NO. 5 - COMMUNICATION AND AUTOMATION

TITLE		TDC PROJECT NUMBER	TOTAL AUTHORIZED			ACTUAL DISBURSEMENTS During 4th Quarter FY 85/86 (Jan.1 - March 31, 1986)			ACTUAL DISBURSEMENTS Total For FY 1985/86			ACTUAL DISBURSEMENTS Total to End FY 1985/1986(6) (March 31, 1986)		
			ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL
MAINLINE RAILWAY APPLICATION OF LICS														
Study of LICS on Mainline Railway	(C)	4510	491.2	--	491.2	0.0	--	0.0	0.0	--	0.0	491.2	--	491.2
LICS Train Control Impl. and Demo	(C)	8929	163.1(1)	--	163.1	0.0	--	0.0	0.0	--	0.0	163.1(1)	--	163.1
On-Board Hot Box Detectors	(C)	4508	17.7(2)	--	17.7	0.0	--	0.0	0.0	--	0.0	17.7(2)	--	17.7
On-Board Hot Box Detectors	(C)	4835	--	18.0(3)	18.0	--	0.0	0.0	--	0.0	0.0	--	18.0(3)	18.0
Automatic Rail Car Identification		4436	250.0	--	250.0	0.0	--	0.0	0.0	--	0.0	165.2	--	165.2
Automatic Rail Car Identification		4437	--	170.0(4)	170.0	--	0.0	0.0	--	0.0	0.0	--	170.0(4)	170.0
End-of-Train Monitoring	(C)	4924	153.0	50.0(5)	203.0	0.0	0.0	0.0	0.0	0.0	0.0	153.0	50.0(5)	203.0
Further Dev. E-O-T Monitoring		6271	250.0	--	250.0	32.6	--	32.6	93.3	--	93.3	244.6	--	244.6
Lampchanger for Railway Signal	(C)	4812	42.5	8.9(5)	51.4	0.0	0.0	0.0	0.0	0.0	0.0	42.5	8.9(5)	51.4
Railway Colour Light Signal	(C)	4980	103.7	--	103.7	0.0	--	0.0	0.0	--	0.0	103.7	--	103.7
Railway Colour Light Signal Phase 2	(C)	6292	123.9	--	123.9	0.0	--	0.0	52.0	--	52.0	123.3	--	123.3
Signal Trans Tech Freight Train	(C)	6053	9.7	13.5(5)	23.2	0.0	0.0	0.0	0.0	0.0	0.0	9.7	13.5(5)	23.2
ATCS Test Bed Development		6622	--	137.4(5)	137.4	--	0.0	0.0	--	0.0	0.0	--	0.0	0.0
ATCS Test Bed Development		6623	82.6	--	82.6	82.6	--	82.6	82.6	--	82.6	82.6	--	82.6
Railway Radio Oper. Power Switch		6628	98.5	--	98.5	35.5	--	35.5	35.5	--	35.5	35.5	--	35.5
TOTAL COMMUNICATION AND AUTOMATION			1785.9	397.8	2183.7	150.7	0.0	150.7	263.4	0.0	263.4	1632.1	260.4	1892.5

(C) Completed
(1) Portion of Total Authorization and Actual Disbursement from this project applicable to ARFP.
(2) Includes credit of 66.7 for financial contribution received from Industry (Projects #4860 & 4861)
(3) ER&D - Trn.
(4) DSS Bridge Funding
(5) TDC O&M
(6) Including Previous Years

AUTHORIZATIONS AND ACTUAL DISBURSEMENTS - FEDERAL FUNDS ($000)
AS OF MARCH 31, 1986

PROGRAM ELEMENT NO. 6 - PROGRAM SUPPORT

TITLE	TDC PROJECT NUMBER	TOTAL AUTHORIZED			ACTUAL DISBURSEMENTS During 4th Quarter FY 85/86 (Jan.1 - March 31, 1986)			ACTUAL DISBURSEMENTS Total For FY 1985/86			ACTUAL DISBURSEMENTS Total to End FY 1985/1986(2) (March 31, 1986)		
		ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL	ARFP	OTHER	TOTAL
Rail Freight R&D Tech. Support (C)	4507	91.9	--	91.9	0.0	--	0.0	0.0	--	0.0	86.6	--	86.6
Rail Freight R&D Tech. Support (C)	4539	15.0	--	15.0	0.0	--	0.0	0.0	--	0.0	15.0	--	15.0
ARFP Technical Support	6310	50.0	--	50.0	3.7	--	3.7	21.4	--	21.4	36.0	--	36.0
ARFP Technical Support	6311	--	24.8(1)	24.8	--	0.0	0.0	--	0.0	0.0	--	0.0	0.0
Evaluation ARF Program (C)	6025	65.0	--	65.0	0.0	--	0.0	0.0	--	0.0	64.9	--	64.9
Update of Rail Freight Eval (C)	6429	33.5	--	33.5	0.0	--	0.0	29.1	--	29.1	32.3	--	32.3
Rail Freight Background Paper	6412	25.0	--	25.0	15.0	--	15.0	25.0	--	25.0	25.0	--	25.0
DSS Science Procurement Fees (C)	8877	32.9	--	32.9	0.0	--	0.0	0.0	--	0.0	32.9	--	32.9
DSS Science Procurement Fees (C)	4783	65.0	--	65.0	0.0	--	0.0	0.0	--	0.0	63.1	--	63.1
DSS Science Procurement Fees (C)	4784	72.0	--	72.0	0.0	--	0.0	0.0	--	0.0	71.5	--	71.5
DSS Science Procurement Fees (C)	6193	7.0	--	7.0	0.0	--	0.0	0.0	--	0.0	6.2	--	6.2
DSS Science Procurement Fees	6522	65.0	--	65.0	11.0	--	11.0	20.2	--	20.2	20.2	--	20.2
DSS Science Procurement Fees	6524	65.0	--	65.0	11.2	--	11.2	16.1	--	16.1	16.1	--	16.1
DSS Science Procurement Fees	6526	65.0	--	65.0	0.0	--	0.0	0.0	--	0.0	0.0	--	0.0
TOTAL PROGRAM SUPPORT		652.3	24.8	677.1	40.9	0.0	40.9	111.8	0.0	118.8	469.8	0.0	469.8

(C) Completed
(1) TDC O&M
(2) Including Previous Years

APPENDIX 2

PUBLISHED REPORTS
AUGMENTED RAIL FREIGHT PROGRAM

PUBLISHED REPORTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM
(Available in limited quantities from TDC)

- Engineering Study for an Electrification Demonstration Project with the Cartier Railway Company, by L.C. Tait et al, Canadian Pacific Consulting Services Ltd., TP 3525E (Final Report)

- Engineering Study for an Electrification Demonstration Project with the Cartier Railway Company, by L.C. Tait et al, Canadian Pacific Consulting Services Ltd., TP 3611E (Summary Report)

- Étude technique relative au projet pilote d'électrification d'un tronçon de voie ferrée appartenant à la compagnie de chemin de fer Cartier, par L.C. Tait et al, Société d'études et de consultation du Canadien Pacifique Ltée., TP 3611F (Rapport sommaire)

- Concept Definition of Wayside Energy Storage Systems (WESS) for Railway Electrification by Turner, A.B. et al, SNC Inc., TP 3622E (Final Report)

- Concept Definition of Wayside Energy Storage Systems (WESS) for Railway Electrification, by Turner, A.B. et al, SNC Inc., TP 3610E (Summary Report)

- Définition du concept de systèmes de stockage d'énergie en bordure des voies ferrées pour l'électrification ferroviaire, par Turner, A.B. et al, SNC Inc., TP 3610F (Rapport sommaire)

- Electrification Study for British Columbia Railway Tumbler Ridge Branch Line, by M. Sugimoto, Canadian Pacific Consulting Services Ltd., and D.R. Stirling, Canac Consultants Ltd, (Canalog Division), TP 3619E (Final Report)

- Unit Train Operations on an Electrified British Columbia Railway Tumbler Ridge Branch Line, by M. Sugimoto, Canadian Pacific Consulting Services Ltd., and D.R. Stirling, Canac Consultants Ltd., (Canalog Division), TP 3691E (Final Report)

- Rail Wear Cost Model User's Manual, by E.R. McIlveen et al, Canadian Institute of Guided Ground Transport, TP 3727E (User's Manual)

- MSERD Rail Freight Transportation Research and Development Program Year-End Report FY 1981/82, by TDC, TP 3756E (Status Report)

PUBLISHED REPORTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

- Evaluation Criteria and Detailed Planning for Two-Axle Locomotive Steerable Truck, by P.G. Whitby, Bombardier Inc., Railway and Diesel Products Division, TP 3851E (Final Report)
- MSERD Rail Freight Transportation Research and Development Program First Quarter Report FY 1982/83, by TDC, TP 3756E (Status Report)
- CRC Pusher Operations Trains Simulations Study, by L.C. Tait and W.R.H. Richardson, Canadian Pacific Consulting Services Ltd., TP 3920E (Final Report)
- MSERD Rail Freight Transportation Research and Development Program, Second Quarter Report FY 1982/83, by TDC, TP 3756E (Status Report)
- Modelling the Response of an LPG-Carrying Rail Tank Car to an External Environment - Phase I, by T. Currie and D.A.J. Millar, Davis Engineering Ltd., TP 3987E (Final Report)
- Modelling the Response of an LPG-Carrying Rail Tank Car to an External Fire Environment, By T. Currie and D.A.J. Millar, Davis Engineering Ltd., TP 4198 (Summary Report)
- Tank Car Thermal Modelling - Phase I, by A. Firmin et al, H.G. Engineering Ltd., TP 3988E (Final Report)
- Railway On-Board Hot Box Detector Evaluation, by K.J.R. Mathewson et al, DSL Dynamic Sciences Ltd., TP 4055E (Final Report)
- Railway On-Board Hot Box Detector Evaluation, by K.J.R. Mathewson et al, DSL Dynamic Sciences Ltd., TP 4219E (Summary Report)
- Augmented Rail Freight Transportation Research and Development Program, Third Quarter Report FY 1982/83, by TDC, TP 3756E (Status Report)
- Canadian Railway Electrification Standards: A Discussion Paper, by R.G. Black and P.D. Frazier, Canadian Institute of Guided Ground Transport, TP 4206E (Final Report)
- Study on Standards for Railway Electrification, by L.C. Tait and A. Gilders, Canadian Pacific Consulting Services Ltd., TP 4578E (Final Report)
- Bending Tests on Wood, Steel and Worn Rail Catenary Masts, by L.C. Tait et al, Canadian Pacific Consulting Services Ltd., TP 4329E (Final Report)

PUBLISHED REPORTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

- Evaluation of "Modelling the Response of an LPG-Carrying Rail Tank Car to An External Fire Environment Phase I" by Davis Engineering Ltd., by J.S.E. Venart, Fire Science Centre, University of New Brunswick, TP 4323E (Final Report)

- Evaluation of "Tank Car Thermal Modelling Phase I" by H.G. Engineering, by J.E.S. Venart, Fire Science Centre University of New Brunswick, TP 4322E (Final Report)

- Tank Car Thermal Modelling: CIGGT Evaluation of Phase I Reports, by A.M. Birk, Canadian Institute of Guided Ground Transport, TP 4286E (Final Report)

- A Canadian Dynamic Controlled-Climate Test Facility Feasibility Study, by J.D. Jackson and V. Usumeri, DSMA International Inc., TP 3976 (Final Report)

- A Canadian Dynamic Controlled-Climate Test Facility Feasibility Study, by J.D. Jackson and V. Usumeri, DSMA International Inc., TP 3977 (Summary Report)

- A Canadian Dynamic Controlled-Climate Test Facility Feasibility Study, by J.D. Jackson and V. Usumeri, DSMA International Inc., TP 3971 (User Interview Summaries)

- A Proposed Canadian Dynamic Controlled-Climate Test Facility For Railway and Heavy Equipment Testing, TP 4182E (A Two-Page Brochure)

- Establishment of Quantitative Wear and Fatigue Model for Railway Rail - 1981/82 Progress Report, by J. Kalousek and H. Ghonem, National Research Council of Canada/University of Rhode Island, TP 4347E (Progress Report)

- Laboratory Research, Analyses and Testing of Improved Austenitic Manganese Steels For Railway Applications, by W.B.F. Mackay and R.W. Smith, Canadian Institute of Guided Ground Transport, TP 4366E (Final Report)

- Rail Profile Grinding, by S.T. Lamson, Canadian Institute of Guided Ground Transport, TP 3998E (Final Report)

- CN All-Weather Mainline Track Switch: Conceptual Design, by A. van Eyken, Canadian Institute of Guided Ground Transport, TP 4425E (Final Report)

- EXPLOSAFE ^{TM} Installation Design, by A.J. Bosik, Davis Engineering Ltd., and D.W. Patterson, Whiteshell Nuclear Research Establishment Atomic Energy of Canada Ltd., TP 4398E (Final Report)

PUBLISHED REPORTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

- British Columbia Railway Tumbler Ridge Branch Line Electrification Power Supply System Design, by G.B. Furst and P. Biller, Canadian Pacific Consulting Services Ltd., TP 4899E (Final Report)

- Railway Electrification - Engineering and Sourcing, Overhead Contact System, by M. Sugimoto and L.C. Tait, Canadian Pacific Consulting Services Ltd., TP 4950E (Final Report):

  3 Volumes - Vol. I: Design and Procurement
  Vol. II: Material Specifications
  Vol. III: Component and Assembly Drawings

- Conception of a Wheel/Rail System Test Rig, by Pierre P. Marcotte, DSL Dynamic Sciences Ltd., TP 4953E (Final Report)

- Design of a Single Cylinder Medium Speed Research Engine and Test Facility, by M.L. Payne, Bombardier Inc., Rail and Diesel Products Division, TP 4844E (Final Report)

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- Evaluation of Design Alternatives for a Freight Train Controller, by K.Y. Wong, M.M. Bayoumi, M.E. Ahmed and I.C. Oszoy, Canadian Institute of Guided Ground Transport, TP 5114E (Final Report)

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- Railway Colour Light Signal, Preliminary Design, by J.H. Lougheed and D. Wong, W.R. Davis Engineering Ltd., TP 5452E (Final Report)

- Location, Identification and Control System Application to Mainline Railroads, by R.C. Chillman and R.J. Pomeroy, Glenayre Electronics Ltd., TP 5032E (Final Report)

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- Train Data Recording System, by R.J. Clark, A. Ferguson and G. Guevara, MPB Technologies Inc., TP 5105E (Final Report)

- Establishment of Quantitative Wear and Fatigue Model for Railway Rail Subjected to Heavy Traffic Conditions and Different Lubrication Regimes, by J. Kalousek, National Research Council of Canada, TP 5346E (Progress Report October 1982 to September 1983)

- Augmented Rail Freight Transportation Research and Development Program, Year-End Report FY 1983/1984, by TDC, TP 3756E (Status Report)

- Design, Construction and Performance Monitoring of Electrification Poles and Foundations of B.C. Rail's Tumbler Ridge Branch Line, by J.C. Leighton, BC Rail, TP 5830E (Final Report)

- A Computer Simulation Analysis of Electric Locomotive Sway, by R.J. Anderson and G.W. English, Canadian Institute of Guided Ground Transport, TP 5585E (Final Report)

- Container Terminal Simulation Model User's Manual, by M.A. MacIsaac et al, CN Rail, TP 5758E

- Container Terminal Simulation Model, by M.A. MacIsaac et al, CN Rail, TP 5759E (Summary Report)

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- Conceptual Design of Snow Removal Equipment for Main Tracks - Snowmaster, by A. van Eyken and S. Perlin, Canadian Institute of Guided Ground Transport, TP 5289E (Final Report)

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- Train Data Recording System Phase III, Laboratory and Field Test Support, by R.J. Clark and G.F. Guevara, MPB Technologies Inc., TP 6146E (Final Report)

- Electric Locomotive Performance Tests on the B.C. Rail Tumbler Ridge Branch Line, by P.H. Bridge, B.C. Rail, TP 6203E (Final Report). **This report is non-releasable.**

- Design & Evaluation of 2-Axle Steerable Locomotive Trucks, by W. Pak and D.D. Taylor, Bombardier Inc., TP 5959E (Final Report). **This report is non-releasable**

- Railway Tunnelling in Rock Using Tunnel Boring Machines, by R.M. Renfrew, Canadian Institute of Guided Ground Transport, TP 6139E (Final Report)

PUBLISHED REPORTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

- Design and Development of an Automatic Lamp Changer for Railway Searchlight Signals, by Byrne Bramwell, Hovey & Associates (1979) Ltd., TP 5757E (Final Report)

- Switcher Locomotive Conceptual Study, by H. Huber, Bombardier Inc., TP 5732E (Final Report)

- CIGGT Track Research Program, by S.T. Lamson and C.A. Dixon, Canadian Institute of Guided Ground Transport, TP 6204E (Interim Report)

- Review of Signal and Power Transmission Technology for Freight Trains, by G.J.M. Aitken, Canadian Institute of Guided Ground Transport, TP 5704E (Final Report)

- Review of Signal and Power Transmission Technology for Freight Trains, by G.J.M. Aitken, Canadian Institute of Guided Ground Transport, TP 5703E (Summary Report)

- Revue des technologies pour la transmission de signaux et de puissance sur les trains de marchandises, par G.J.M. Aitken, Canadian Institute of Guided Ground Transport, TP 5703F (Rapport Sommaire)

- Rail Profile Grinding - Phase II Test Report, by S.T. Lamson, Canadian Institute of Guided Ground Transport, TP 6175E (Final Report)

- Augmented Rail Freight Transportation Research and Development Program, Third Quarter Report FY 1984/85, by TDC, TP 3756 (Status Report)

- Soil Suction Measurement, by P. Van der Raadt, Clifton Associates Ltd., TP 6661E (Final Report)

- Induction Hardening of Carbon Steel Rail for Railway Track - A Laboratory Investigation of Technique, by T. Edward Whittick, Permatrack Systems Inc., TP 6288E (Final Report) **This report is non-releasable**

- Establishment of Quantitative Wear & Fatigue Model for Railway Rail - 1984/85, Progress Report, by J. Kalousek et al, National Research Council of Canada, TP 6939E (Progress Report)

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PUBLISHED REPORTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

- Augmented Rail Freight Transportation Research and Development Program, Second Quarter Report FY 1985/86, by TDC, TP 3756E (Status Report)
- Cost Benefit Study of the Electrification of the BC Rail Tacheeda to Prince George Line, by J. Popoff, BC Rail, TP 7234E (Final Report)
- Doppler Radar Locomotive Speedometers (Radometers) - CMI Inc., Field Evaluation, by K.H. Kilpatrick, R.J. Lusk and R. Lauzon, CN Rail, TP 6808E (Final Report)
- Validation and Testing of the Rail Tank-Car Thermal Analysis Program (TNKCAR), by A.M. Birk, Davis Engineering Ltd., TP 6693E (Final Report)
- Validation and Testing of the Tank-Car Thermal Analysis Program (TNKCAR) - Summary Report, by A.M. Birk, Davis Engineering Ltd., TP 6910E (Summary Report)
- Fire Tests to Study the Significance of a Burning Relief Valve Flare from a Tank-Car Engulfed in a Fire, by A.M. Birk, Davis Engineering Ltd., TP 6694E (Final Report)
- Radial Axle Truck Tests, by V. Khatchadourian et al, Canadian Pacific Ltd., TP 6859E (Final Report)
- End-of-Train Monitoring System, by Dr. R.J. Pomeroy and D. Rees-Thomas, Glenayre Electronics Ltd., TP 6057E (Final Report)
- Railway Colour Light Signal: Phase II - Prototype Development, by J.H. Lougheed, D. Wong and L. Davidson, W.R. Davis Engineering Ltd., TP 6877E (Final Report). **This report is non-releasable.**
- Railway Electrification Guidelines, by Canadian Standards Association, C22.3 No. 8-M1986 (available from CSA)
- The Electrification of the Tumbler Ridge Branch Line, by H. Lockhart, BC Rail, TP 7625E (Final Report)
- Evaluation of the Location, Identification and Control (L.I.C.) Systems in an Electrified Railway Environment, by G.D. Taylor, D.O. Gudmundson and E.W. Shaw, BC Rail, TP 7269E (Final Report)
- CIGGT Track Research Program, Interim Report, November 1983 - November 1984, by S.T. Lamson and C.A. Dixon, Canadian Institute of Guided Ground Transport, TP 6024E (Interim Report)
- CIGGT Track Research Program, Interim Report, November 1984 - November 1985, by S.T. Lamson and C.A. Dixon, Canadian Institute of Guided Ground Transport, TP 7417E (Interim Report)

PUBLISHED REPORTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

- Subballast and Geotextiles for Railway Track Support Separation Applications, by G.P. Raymond, Canadian Institute of Guided Ground Transport, TP 7383E (Final Report)

- Probabilistic Analysis of Railway Tracks, by H.A. El-Ghazaly and A.N. Sherbourne, University of Waterloo and F. Arabi, Michigan Technological University, TP 7294E (Final Report)

- High Productivity Integral Train Conceptual Designs, by S.F. Smith et al, Transportation Technology Ltd., TP 7119E, appendices in Vols. 2 and 3 (Final Report)

- Laboratory Evaluation of a Train Data Recording System, by Lloyd C. Kremer, Warnock Hersey Professional Services Ltd., TP 7496E (Final Report)

- Augmented Rail Freight Transportation Research and Development Program, Third Quarter Report FY 1985/86, by TDC, TP 3756E (Status Report)

APPENDIX 3

COMPLETED PROJECTS
AUGMENTED RAIL FREIGHT PROGRAM

COMPLETED PROJECTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM

PROJECT NO.	PROJECT TITLE	OUTPUT(1)
4260 & 4267	Railway Electrification Demonstration Engineering Study	TP 3525E, TP 3611E, TP 3611F
4585	Railway Electrification Demonstration Signal Design	Typical Track Circuit(2) Layouts and Specifications
4586	Railway Electrification Demonstration Mast Tests	Purchase and delivery to NRC for evaluation and testing of four differently configured catenary masts and hardware
4587	Electrification Study for BC Rail Tumbler Ridge Branch Line	TP 3619E
4458	Energy Storage for Railway Electrification	TP 3622E, TP 3610E, TP 3610F
4720	Operations Research Analysis of BC Rail Tumbler Ridge Branch Line	TP 3691E
4570	CIGGT Rail Wear Model Enhancement	TP 3727E
4717	Evaluation Criteria and Detailed Planning for Two-Axle Locomotive Steerable Truck	TP 3851E
4723	Cartier Railway Co. Pusher Operations Train Simulation Study	TP 3920E
4933	BC Rail Elect'n. Catenary Manufacturing Drawings	Drawings and Specifications for 50kV cateary system (2)
4468 & 4836	Tank Car Thermal Modelling	TP 3988E
4559 & 4837	Tank Car Thermal Modelling	TP 3987E
4721	Test Instrumentation Rail Grinding	Information generated included in final report for project 4562
4508 & 4835	On-Board Hot Box Detectors	TP 4055E, TP 4219E

COMPLETED PROJECTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

PROJECT NO.	PROJECT TITLE	OUTPUT(1)
4713	Assembly of Railway Electrification Standards	TP 4206E
4523	Study on Standards for Railway Electrification in Canada	TP 4578E
4887	Testing Catenary Masts for Railway Electrification	TP 4329E
4710/ 4838	Thermal Modelling Evaluation	TP 4322E, TP 4323E
4728/ 4839	Thermal Modelling Evaluation	TP 4286E
4089	Controlled-Climate Facility II	TP 3976, TP 3977, TP 3971, TP 4182E
4467	Austenitic Manganese Steel	TP 4366E
4522	Rail Wear and Fatigue Model	TP 4347E
4562	Rail Grinding Optimization	TP 3998E
4575	Rly. Switch Operable in Snow & Ice	TP 4425E
4982/ 4576	EXPLOSAFE Installation Design, Ph. II	TP 4398E
4786	BCR Electrification - Substation	TP 4899E
4760	Rail Electrification Demo - Catenary Study	TP 4950E
4722	Wheel/Rail Bearing and Brake Test Rig	TP 4953E
4558	Diesel Combustion	TP 4844E
4471	Train Control Scheme Development	TP 5114E
6007	Drafting of Electrification Standards	TP 5256E
4980	Railway Colour Light Signal	TP 5452E
4510/ 8929	Study of LICS on Mainline Railway	TP 5032E, TP 5217E

COMPLETED PROJECTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

PROJECT NO.	PROJECT TITLE	OUTPUT(1)
4462/63 & 4983	Train Data Recording Systems	TP 5105E
4830	Rail Wear and Fatigue Model Phase 2	TP 5346E
4785	BC Rail Electrification - Catenary Tests	TP 5830E
6165	Electric Locomotive Sway	TP 5585E
4905/ 4604	Intermodal Terminal Simulation	TP 5758E, TP 5759E, TP 5759F
6038	Snowmaster Conceptual Design	TP 5289E
6109	TDRS Lab & Field Test Support	TP 6146E
6032/33	B.C. Rail Elect'n. Loco. Testing	TP 6203E
4715	Two-Axle Locomotive Steerable Truck	TP 5959E
6125	TBM Evaluation	TP 6139E
4812	Lampchanger for Railway Signal	TP 5757E
4588	Shunter Locomotive Design	TP 5732E
6053	Review of Signal Transmission Technology for Freight Trains	TP 5703E, TP 5703F TP 5704E
6011	Rail Profile Grinding, Ph. II	TP 6175E
6305	Soil Suction Measurement	TP 6661E
6136/37	Induction Track Hardening	TP 6288E
6138	TDC/CP Research Program 1984	TP 6660E
6155	Rail Wear & Fatigue Model Ph. 3	TP 6939E
6408	Elect. Tacheeda - Prince George Line	TP 7234E
4530	Radar Speedometer Evaluation	TP 6808E

COMPLETED PROJECTS - AUGMENTED RAIL FREIGHT TR&D PROGRAM (cont'd)

PROJECT NO.	PROJECT TITLE	OUTPUT(1)
4917/18	Tank Car Thermal Computer Model	TP 6693E
4917/18	Tank Car Thermal Computer Model	TP 6910E
4917/18	Tank Car Thermal Computer Model	TP 6694E
6132	Radial Axle Truck Testing	TP 6859E
4924	End-of-Train Monitoring	TP 6057E
6292	Railway Colour Light Signal (Ph. 2)	TP 6877E
6309	Rail Electrification Guidelines	C22.3 No.8-M1986(3)
4960/61	BC Rail Elect'n.-System Documentation	TP 7625E
4908/09	BC Rail Elect'n.-LICS	TP 7265E
6012	Computer Analysis of Railway Tracks	TP 7294E
6340	HI Productivity Integral Train	TP 7119E
4800	Lab Evaluation of Train Rec. System	TP 7496E

(1) For TP report titles see Appendix 2.
(2) May be viewed at TDC. Contact Chief, Current Technology Division
(3) Available from CSA